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SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS ANNOUNCEMENT 1912-13

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This announcement is intended to give detailed information to prospective students in the Sibley College of Mechanical Engineering and the Mechanic Arts of Cornell University.

For general information concerning the University and its various colleges, the requirements for admission, etc., the General Circular of Information should be consulted. This and the other Official Publications of Cornell University are listed on the last page of the cover of this pamphlet. Any one of the informational publications there mentioned will be sent gratis and post-free on application to The Registrar of Cornell University, Ithaca, N. Y.

CALENDAR

1912-13

Sept. 13,	Friday,	Entrance examinations begin.
Sept. 23,	Monday,	Academic year begins. Registration of new students. Scholarship examinations begin.
Sept. 24,	Tuesday,	Registration of new students.
Sept. 25,	Wednesday,	Registration of old students.
Sept. 26,	Thursday,	Instruction begins. President's annual address to the students.
Sept. 28,	Saturday,	Registration, Graduate School.
Oct. 15,	Tuesday,	Last day for payment of tuition.
Nov.	Thursday–Friday,	Thanksgiving recess.
Dec. 23,	Monday,	Instruction ends } Christmas Recess.
Jan. 6,	Monday,	Instruction resumed }
Jan. 11,	Saturday,	Founder's Day.
Jan. 27,	Monday,	Term examinations begin.
Feb. 8,	Saturday,	Registration, undergraduates.
Feb. 10,	Monday,	Registration, Graduate School.
Feb. 10,	Monday,	Instruction begins.
Feb. 29,	Friday,	Last day for payment of tuition.
April 2,	Wednesday,	Instruction ends. { Spring Recess.
April 8,	Tuesday,	Instruction resumed {
May 31,	Saturday,	Navy Day,
June 2,	Monday,	Term examinations begin.
June 10,	Thursday,	Commencement.

1913-14

Sept. 12,	Friday,	Entrance examinations begin.
Sept. 22,	Monday,	Academic year begins. Registration of new students. Scholarship examinations begin.
Sept. 23,	Tuesday,	Registration of new students.
Sept. 24,	Wednesday,	Registration of old students.
Sept. 25,	Thursday,	Instruction begins. President's annual address to students.

SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
Albert William Smith, B.M.E., M.M.E., Director of the College, Dean of the Faculty, and Professor of Power Engineering, in charge of the department.
Rolla Clinton Carpenter, M.S., C.E., M.M.E., LL.D., Professor of Experimental Engineering, in charge of the Department of Engineering Research.
Dexter Simpson Kimball, A.B., Professor of Machine Design and Construction, in charge of the department.
Henry Hutchinson Norris, M.E., Professor of Electrical Engineering, in charge of the department.
George Robert McDermott, Professor of Structural Design.
Herman Diederichs, M.E., Professor of Experimental Engineering, in charge of the department.
William Nichols Barnard, M.E., Professor of Power Engineering, and Secretary of the College.
Vladimir Karapetoff, C.E., Professor of Electrical Engineering.
Clarence Floyd Hirshfeld, B.S., M.M.E., Professor of Power Engineering.
Howard Drysdale Hess, M.E., Professor of Machine Design.
Edgar Harper Wood, M.M.E., Professor of Mechanics of Engineering, in charge of the department.
George Stanley Macomber, M.E., Assistant Professor of Electrical Engineering.
Calvin Dodge Albert, M.E., Assistant Professor of Machine Design.
Will Miller Sawdon, B.S., M.M.E., Assistant Professor of Experimental Engineering, assigned to the Department of Engineering Research.
Walter Stebbins Ford, M.E., Assistant Professor of Electrical Engineering.
George Burr Upton, M.M.E., Assistant Professor of Experimental Engineering.
Leslie David Hayes, M.E., Assistant Professor of Machine Design.
Seymour Stanton Garrett, C.E., Assistant Professor of Mechanics of Engineering.
Albert Edward Wells, Superintendent of Shops and Instructor in Machine Construction.
Robert Long Daugherty, A.B., Acting Assistant Professor of Mechanics of Engineering.
Frank Oakes Ellenwood, A.B., Acting Assistant Professor of Power Engineering.
John Tainsh Williams, Instructor in Machine Design.
Charles Homer Tower, S.B., Instructor in Electrical Engineering.
John F. H. Douglas, B.Sc., Instructor in Electrical Engineering.
Henry Livingston Freeman, M.E., Instructor in Machine Design.
Clarence Walter Ham, M.E., Instructor in Machine Design.
Victor Raymond Gage, M.E., Instructor in Experimental Engineering.
Frank Girard Tappan, M.E., Instructor in Electrical Engineering.
John Floyd Stevens, M.E., Instructor in Electrical Engineering.
Tom Bruce Hyde, M.E., Instructor in Engineering Research.
Robertson Matthews, M.E., Instructor in Power Engineering.
Daniel Robert Francis, E.E., B.A., Instructor in Machine Design.
Preston Littlepage Peach, M.E., Instructor in Machine Design.
Herbert McNair Douglass, M.E., Instructor in Mechanics of Engineering.
W. Rodney Cornell, B.Sc., C.E., Instructor in Mechanics of Engineering.
Arthur Graham Bierma, M.E., Instructor in Experimental Engineering.
Guy Leroy Current, B.S. in E.E., Instructor in Experimental Engineering.
Leroy Alonzo Wilson, M.E., Instructor in Power Engineering.
William Roy Wigley, M.E., Instructor in Experimental Engineering.
Henry Mark Parmley, M.E., Instructor in Power Engineering.
Fred Edgar Klinck, M.E., Instructor in Machine Design.
Myron A. Lee, M.E., Instructor in Machine Design.
Jerome Arthur Fried, M.E., Instructor in Mechanics of Engineering.

Charles Dudley Corwin, M.E., Instructor in Machine Design.
Warren Howard Hook, M E., Instructor in Experimental Engineering.
Joseph Franklin Putnam, M.E., Instructor in Experimental Engineering.
Stephen Remington Wing, M.E., Instructor in Experimental Engineering.
Paul Wheeler Thompson, M.E., Instructor in Power Engineering.
Tomlinson Carlile Ulbricht, M.E., Instructor in Power Engineering.
John George Pertsch, M.E., Instructor in Electrical Engineering.
Dale Stevens Cole, B.S. in E.E., Instructor in Electrical Engineering.
Earle Smead Burnett, B.S. in M.E., Instructor in Experimental Engineering.
Clarence Ellsworth Townsend, M.E., Instructor in Machine Design.
Stephen J. Fuller, M.E., Instructor in Electrical Engineering.
William Cyrus Ballard, M.E., Instructor in Electrical Engineering.
Clarence Andrew Peirce, A.B., M.E., Instructor in Machine Design.
Emil Adler, M.E., Instructor in Machine Design.
John Randolph Cautley, M.E., Instructor in Machine Design.
Paul Burns Eaton, M.E., Instructor in Machine Design.
John Randolph DuPriest, B.S. in E.E., Instructor in Machine Design.
Grover Cleveland Mills, B.M.E., Instructor in Machine Design.
Henry Lawrence Beecher, B.S., Instructor in Machine Design.
Clarence Vincent Elliott, M.E., Instructor in Machine Design.
William James Thorne, M.E., Instructor in Machine Design.
Gardiner Merriam Rogers, M.E., Instructor in Experimental Engineering.
Charles Ketchum Carpenter, M.E., Instructor in Experimental Engineering.
Alexander Chilson Stevens, M.E., Instructor in Electrical Engineering.
Robert Franklin Chamberlain, M.E., Instructor in Electrical Engineering.
Robert Louis Stevenson, B.S. in E.E., Instructor in Electrical Engineering.
Lester William Wallace Morrow, M.E., Instructor in Electrical Engineering

Assistants

James Eugene Vanderhoef, Foreman of Foundry.
Walter Liston Head, Foreman of Forge Shop.
Leroy Hooper, Foreman of Wood Shop.
Raynor Egbert Seamon, Assistant in Wood Shop.
Birdette Newton Howe, Assistant in Machine Shop.
Howard Stanley Bush, Assistant in Wood Shop.
Ward Brown Smith, Assistant in Machine Shop.
Charles Albert Brooks, Assistant in Forge Shop.
David John Davies, Assistant in Foundry.
Charles Hubert Sweet, Assistant in Wood Shop.
William Benjamin Buck, Assistant in Machine Shop.
George Washington Race, Mechanician in Sibley College.
Edward Warren Gregory, Mechanician.
Charles Alfred Culligan, Mechanician.
Charles Bedell, Engineer.

Margaret Isabelle Colquhoun, Clerk in Experimental Engineering.
Fanny Elma Mix, Secretary to the Director.
Rowena L. Shephard, College Librarian.

PURPOSES OF INSTRUCTION

The College is organized not only to teach the fundamental principles that underlie all mechanical engineering, but also to give such practical training and such instruction in the economics of engineering as is possible in a technical school.

It is well recognized that theoretical instruction must be supplemented by experience in practice and by contact with life before one can attain his greatest usefulness in the profession; hence, in Sibley College, an effort is made to bring the student into contact with teachers who are closely in touch with commercial engineering practice, to the end that he may thus become familiar with problems encountered in modern engineering and with commercial methods of solving them. It is hoped in this way to shorten somewhat the period of adjustment for the graduate when he begins actual engineering work.

The success of an engineer has come more and more to depend upon his ability to meet men of education and culture on equal terms; and, since the work in the regular four-year course in this college is almost wholly technical, the student before entering the college should have a thorough general education, and if possible, the training of a liberal college course. Those who have not had this broader education should, if possible, spend one or two years in the College of Arts and Sciences. A five-year course for mechanical engineers, including the equivalent of one year in this latter college, is outlined on page 21; and a six-year course leading to the degrees of A.B. and M.E. is described on page 22. The entrance requirements for these courses are the same as for the College of Arts and Sciences and demand less mathematical preparation than is specified for the four-year engineering course.

In addition to the prescribed courses in Sibley College those students who have the necessary time available may elect, with the permission of their class adviser, any course in any college of the University, provided they have had the required preparation for the work.

ADMISSION AND CLASSIFICATION

The following four classes of students are admitted to the work of the Sibley College of Mechanical Engineering and the Mechanic Arts.

1. Persons that desire to begin as freshmen the regular undergraduate course leading to the degree of Mechanical Engineer.

2. Persons that have already attended some technical or similar institution and desire to enter with advanced standing the regular course in Sibley College leading to the degree of Mechanical Engineer.

3. Persons that desire to enter as special students not candidates for the degree of Mechanical Engineer.

4. Graduate students.

For the five-year course leading to the degree of Mechanical Engineer, see page 21.

For the combined course of six years leading to the degrees of Bachelor of Arts and Mechanical Engineer, see page 22.

1. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS

All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University.

For admission to the four-year course the applicant must be at least sixteen years of age and must offer fifteen entrance units, which must include English three units, history one unit, mathematics four units, and French or German three units. The four remaining units may be chosen from group c, or they may be additional units from group b. The term unit means the equivalent of five recitations a week for one year in a subject. See General Circular of Information.

Subject	Units
Group a	
English A	2
English B	1
Algebra, Elementary	1
Algebra, Intermediate	½
Algebra, Advanced	½
Geometry, Plane	1
Geometry, Solid	½
Plane Trigonometry	½
Group b	
History—Ancient	½ or 1
" Modern	½ or 1
" American, Civics	½ or 1
" English	½ or 1
German—First Year	1
" Second Year	1
" Third Year	1
French—First Year	1
" Second Year	1
" Third Year	1
Group c	
Greek—First Year	1
" Second Year	1
" Third Year	1
Latin—First Year	1
" Second Year	1
" Third Year	1
" Fourth Year	1
Spanish—First Year	1
" Second Year	1
" Third Year	1
Italian—First Year	1
" Second Year	1
" Third Year	1
Spherical Trigonometry	½
Physics	1
Chemistry	1
Physical Geography	1
Biology*	1
Botany*	½–1
Zoology*	½–1
Agriculture	½–1
Drawing	½–1
Manual Training	1

*If an applicant has counted Biology (1) he may not also offer Botany (½) or Zoology (½).

For details concerning entrance subjects and methods of admission see pages 4 to 22 of the General Circular of Information.

For the regulations relating to admission at the beginning of the second term see the next paragraph.

2. ADMISSION TO ADVANCED STANDING

All correspondence concerning admission to advanced standing should be addressed to the Registrar of Cornell University.

A student who, having already attended some technical or similar institution, desires advanced standing in the regular course in the Sibley College of Cornell University should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to advanced standing in Sibley College along with an official certificate from the institution already attended, of his honorable dismissal, his entrance examinations in detail, his terms of attendance and the amount of work that he has completed, and a detailed statement of the courses pursued for which he desires credit at Cornell. He should send also a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

In order to secure admission in the middle of the college year the applicant must place his certificates and credentials in the hands of the Registrar not later than January 15. No one will be admitted as a new student in Sibley College at the beginning of the second term unless, by attendance during the remainder of the college year and during the succeeding Summer Session, he can substantially complete the year's work scheduled for the class he wishes to enter.

On application made to the Registrar on or before January 15 in any year, special entrance examinations in any of the University entrance subjects may be arranged for students who must be examined in one or more subjects to complete their requirements for admission at the middle of the year. These special entrance examinations will be held in Ithaca on or about January 25 of each year.

3. ADMISSION AS SPECIAL STUDENTS

All correspondence concerning the admission of special students should be addressed to the Secretary of Sibley College. All applications for admission must be made on the official blanks provided for the purpose and obtainable from the Secretary.

Men at least twenty-one years of age may be admitted as special students in mechanical engineering not candidates for a degree, provided they have had considerable experience in some line of mechanical engineering and give evidence of ability to do creditable work in the college; and provided they have neither been previously admitted to the University as regular students nor have been refused admission.

They will be required to have completed before admission the mathematical preparation of the regular students,—plane and solid geometry, elementary, intermedia te, and advanced algebra, and plane trigonometry,—and may be held for examination in these subjects. There are no special courses for special students; they must conform to the four-year course as outlined on pages 17 to 19.

Upon fulfillment of all entrance requirements special students may become regular students and candidates for the degree of M.E. Special students will not, however, be permitted to make up deficiencies in entrance subjects by attending University instruction in those subjects.

4. ADMISSION AS GRADUATE STUDENTS

All correspondence relating to graduate work and fellowships should be addressed to the Dean of the Graduate School.

In all departments in Sibley College, work is arranged to meet the special needs of graduate students and, in addition, the head of the Department of Engineering Research will coöperate in every way to assist the graduate students in mechanical and electrical engineering, and will aid in providing apparatus and other facilities for graduate work. Graduate students register in the Graduate School and not in Sibley College. To be registered as a candidate for the degree of Master of Mechanical Engineering, the student must have satisfied the equivalent of the entrance requirements and of the University subjects specified by Sibley College for the M.E. degree. For further information regarding admission, registration, etc., see Announcement of the Graduate School.

GENERAL OUTLINE OF INSTRUCTION

The instruction in mathematics, in chemistry, in physics, and in general economics is given in the College of Arts and Sciences. All other regular subjects in the course are of an engineering nature and are given in Sibley College in the following departments: 1. Mechanics of Engineering; 2. Machine Design and Construction; 3. Experimental Engineering; 4. Power Engineering; 5. Electrical Engineering; 6. Engineering Research.

The following is a brief outline of the scope and purposes of instruction in the various departments.

1. DEPARTMENT OF MECHANICS OF ENGINEERING

Instruction in this department begins with the course in the fundamentals of theoretical and applied mechanics, which is open to those who have had the necessary preliminary courses in analytical geometry and calculus. As the instruction in this subject is in direct preparation for nearly all of the engineering work that follows, the training is made most thorough. In brief, the course includes the mathematical and graphical treatment of statics as applied to material points and rigid bodies (centers of gravity, moments of inertia, forces, couples, framed structures, graphical statics, etc.); the kinetics of material points and rigid bodies, with applications to mechanisms (motions, velocities, accelerations, centrifugal and inertia forces, energy, power, resistance, etc.); and the mechanics of materials, (stresses, strains, and resilience of materials, the forces and moments produced by the loads acting on structural members, and the strength, deflection, and curvature of these members).

Instruction is also given in this department in the elements of hydraulics, including hydrostatics and hydrokinetics, and in the theory of hydraulic motors. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

2. DEPARTMENT OF MACHINE DESIGN AND CONSTRUCTION

The courses in drawing, design, and shopwork, are organized under one department to secure the close correlation of these subjects. Many of the exercises in the drawing room, pattern shop, foundry, and machine shop involve work on the same machine parts. In this way the student has presented to him all the necessary steps in the inception and production of finished machine parts.

Machine Design. Instruction in this branch of the department begins with lettering, the use of drawing instruments, and descriptive geometry, followed by the elements of mechanical drawing according to the best modern practice in commercial drafting rooms.

Following this the student is taught empirical design and the principles of mechanism. The drawing room work in the latter course is closely related to the class room instruction in cams, gearing, and linkages, with application to the kinematic design of machines.

After the student has received instruction in mechanism and applied mechanics, he takes up the mathematical side of machine design, the instruction being given by lectures, recitations, and drawing room work. The student "lays out" mechanisms on the drawing board, analyzes the force, velocity, and energy transformations involved; proportions the members with consideration of strength, rigidity, and shop operations; and makes working drawings for the complete designs of machines.

In the senior year the student has the option of continuing the work of the preceding year, undertaking larger, broader, and more complex problems in the design of engineering structures and in the design, construction, and equipment of mills, factories, power houses, etc.

Shopwork. The object of the instruction in this branch of the department is not only to familiarize the student with modern shop operations and processes, and with the workability of materials used in engineering construction, but more particularly to give him instruction in the principles of manufacturing and duplication of parts, in the selection and arrangement of shop equipment, and in the organization and administration of industrial works.

In the freshman year the student attends lectures on the general principles of engineering; he receives instruction in the foundry in moulding, core making, mixing of metals, operation of cupola, the use of moulding machines, etc., with consideration given to the methods and appliances for sweepwork, large work, and production in quantities; and he is given manual instruction in the forging and heat treatment of both iron and steel supplemented with illustration of drop hammer work and methods used in manufacturing in large quantities.

In the sophomore year wood working is taught with the object not only of familiarizing the student with wood working tools and machines and their use, but more especially to teach him pattern and core-box making. Instruction is also given in large pattern work and sweepwork.

In the junior year the principles of manufacturing are taught by lectures, supplemented by work of illustrative character in the machine shop, where carefully graded instruction is given in the use of measuring instruments, hand tools, and machine tools, including semi-automatic and automatic tools, and in the use of jigs and special fixtures for manufacturing in large quantities. The administration of this shop in particular is intended to illustrate as far as possible approved

methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium plan, and other wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

In the senior year instruction is also given in the organization of industries, the finance of manufacturing, factory legislation, welfare work, rewarding labor, etc.

3. DEPARTMENT OF EXPERIMENTAL ENGINEERING

Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses.

Throughout the junior and senior years the student receives instruction in the very completely equipped mechanical laboratories (described on page 12) not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but to teach him the best methods of research. Briefly, the courses include the use of computing machines; the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, etc.; tests of lubricants; fuel calorimetry; steam calorimetry; valve settings; tests of boilers, steam engines, turbines, pumps, heaters, condensers, and injectors and other steam apparatus; test of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

4. DEPARTMENT OF POWER ENGINEERING

All students in Sibley College receive instruction in this department in their junior and senior years with the object of training them in the methods of solution of problems involved in the theory, design, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work in this department begins with lectures and recitations on the elements of heat-power engineering, which includes the study of elementary thermodynamics of gases and vapors, theoretical and actual cycles, internal and external combustion engines, steam engines, fuels, boilers, producers, and accessories. This course is open to those who have had the necessary preparatory courses in sophomore mechanics and physics.

In their senior year all students in the college take the more advanced lecture, recitation, and computation courses devoted to problems involved in the selection and arrangement of power plant equipment with special attention to economic factors. In addition the student may specialize in this year in the design of steam engines or of internal combustion engines, by taking the lecture and drafting courses specially devoted to these subjects. He may also attend special lecture courses on steam turbines, steam boilers, and gas manufacture.

5. DEPARTMENT OF ELECTRICAL ENGINEERING

Instruction in electrical engineering begins in the junior year and is based on the required courses in physics and mechanics. The instruction begins with the elements of electrical engineering taught by experimental lectures, recitations,

and laboratory exercises. Briefly, this introductory course covers a review of the fundamental laws of electric and magnetic circuits, electrical measurements, and the theory, structural features, and operating characteristics of electrical apparatus.

In the senior year the students who are specializing in mechanical engineering have a brief advanced laboratory course and receive instruction in the solution of such electrical problems as are encountered in general engineering practice.

Those who specialize in electrical engineering receive in the senior year advanced instruction by lectures, recitations, computation exercises, and laboratory experiments. This subject is approached from three points of view: (a) analytical; (b) graphical; and (c) experimental. Each senior follows through a series of problems in which, starting with the data given, he makes application of the fundamental principles involved and predicts the performance of the mechanism or apparatus under various conditions of operation, or for specified performance he determines the necessary dimensions. In the laboratory a large variety of experiments show the characteristics of machines under operating conditions, and familiarize the students with the construction and operation of the various commerical types of electrical apparatus.

During the second term of the senior year a number of courses is offered by specialists in the different departments of the field of electrical engineering, these courses being planned simply to illustrate the manner in which the several industrial requirements are met. Electric railway engineering, telephone engineering, power generation and transmission, and the design of electrical machinery are the topics treated this year. The students do not become engineers or designers in these various fields, but they learn enough of each to appreciate the kind of problems which predominate. Recitations in this work are carried on in small sections, thus securing to the student a large amount of individual attention which is devoted primarily to developing originality and initiative.

6. DEPARTMENT OF ENGINEERING RESEARCH

Engineering research by undergraduate students is carried on in this department, which is in charge of a separate corps of specialists who devote their entire time to this work. Those who have shown proficiency in experimental engineering may have opportunity to conduct original investigations under expert guidance, and, as occasion offers, may assist in commercial tests, made at the University or elsewhere, of materials, prime movers, power plants, etc. The equipment of every department is available for this work and the specialists in any department may be consulted and their assistance may be obtained.

In case the investigation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. Research or thesis work, may be substituted for certain of the regular courses of the senior year. Arrangements for this work should be made with the Department of Engineering Research, during the junior year if possible.

Besides the courses in engineering research and power plant testing, lecture courses, primarily for seniors and graduate students, are given on motor car construction and on heating and ventilating.

This department will coöperate in every way to assist graduate students in

mechanical and electrical engineering and will aid in providing apparatus and other facilities for graduate work.

Non-Resident Lecturers. Supplementing the regular course of instruction, lectures are delivered from time to time by non-resident specialists in the profession.

BUILDINGS AND EQUIPMENT OF SIBLEY COLLEGE

The Sibley College of Mechanical Engineering and the Mechanic Arts receives its name from the late Hiram Sibley of Rochester, who, between the years 1870 and 1887, gave $180,000 toward its endowment and equipment. Mr. Hiram W. Sibley has added more than $130,000 for later constructions. The Sibley buildings are situated at the north end of the Campus, and stand upon ground leased from the University for the purposes of the College, under an agreement with the late Hiram Sibley. There are six large buildings and several smaller ones.

The main building is three hundred and seventy feet long, fifty feet in width, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices, and class rooms, and a large and well-lighted auditorium.

Franklin Hall is occupied on its first two floors and basement by the Department of Electrical Engineering, which in addition uses temporarily a portion of Rand Hall.

The Department of Experimental Engineering occupies a two-story building one hundred and fifty feet long by forty feet wide, a gas engine laboratory forty by sixty feet, a boiler plant thirty by forty feet, an engine room forty by fifty feet, a refrigeration laboratory thirty by forty feet, and the east basement of the main building.

Rand Hall, a new building costing $60,000, has recently been added to the Sibley College group through the generosity of Mrs. Florence O. R. Lang. This building is a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr., the father, uncle, and brother of the donor. It is a three-story building whose main portion is one hundred and seventy feet long and fifty feet wide; it contains the machine shop and pattern shop, and a portion is used temporarily for one of the electrical laboratories.

The foundry and forge shops occupy a one-story building one hundred and eighty feet long and forty feet wide.

The major part of a two-story building one hundred and fifty feet long and forty feet wide is available for engineering research.

WORK SHOPS

A part of the work-shop equipment is installed to illustrate the latest practice in production with specialized labor-saving machinery. The students are not expected to become skilled operators of the machines of this class, but to acquire a general knowledge of their possibilities in the kind of work to which they are adapted.

The foundry occupies floor space of about 4800 square feet, and has an equipment for the production of iron and composition castings. The methods of pro-

ducing duplicate work are demonstrated by moulding machines of different types selected to illustrate the production of castings of various kinds at lowest labor cost.

The forge shop has the usual equipment of standard forges and small tools. There is also a modern drop-forge plant operated by one of the instructing staff. Forging by the drop hammer method, and power press work are frequently demonstrated and discussed with all students.

The pattern shop occupies the top floor of Rand Hall with floor space of 8440 square feet. The work given the students in this department includes the use of hand and power operated tools under instructors who are skilled in the trade of pattern making.

The machine shop is located on the ground floor of Rand Hall with the same floor area as the pattern shop. It is equipped with an electric travelling crane and representative modern machine tools selected with a view of demonstrating manufacturing methods. The equipment is arranged in groups, each in charge of an instructor who has made a special study of the machinery in his group.

MECHANICAL LABORATORIES

The instruction in the Department of Experimental Engineering is given in several separate laboratories, each of which is thoroughly equipped with the machines, apparatus, and instruments necessary for instruction in research.

The Materials Testing Laboratory. This laboratory is equipped for tension and compression tests with an Olsen 300,000 pound machine, a Riehlé 100,000 pound machine, a 200,000 pound Emery hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse tests there is a Riehlé machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There are one Olsen torsion machine of 200,000 inch-pounds capacity, and two Thurston autographic torsion machines. The equipment includes measuring instruments, such as extensometers, a cathetometer, gas furnaces, tempering baths, and other apparatus required for the determination of the physical qualities of engineering materials under tensile, compressive, transverse, and torsional stress, and under different kinds of heat treatment.

The Steam Laboratory. In this laboratory there is a 150 H. P. triple expansion Allis-Corliss engine so fitted up that it may be run as a simple, compound, or triple engine, condensing or non-condensing. There are also many smaller engines, including a Russell, a Harris-Corliss, and two Payne engines. There are three surface condensers which may be connected with these engines as desired. There is one 35 K. W. horizontal Curtis turbine and one 15 K. W. De Laval turbine. These turbines drive electric generators and may be run condensing or non-condensing.

There is a two-stage steam driven Ingersoll-Rand compressor, and three air-brake pumps of different types, together with meters, nozzles, and other instruments used in testing. The action of the air brake may be studied in a complete brake equipment for a 25-car train. This part of the laboratory also contains several motor-driven fans, including one of the Sirocco type.

The equipment of apparatus and instruments used for engine testing comprises about 80 indicators of different types, about 75 steam gauges, a number of calori-

meters for the determination of the quality of steam, speed counters, tachometers, planimeters, etc., besides a number of dynamometers of various kinds.

The boiler section of this laboratory has one 150 H. P. Babcock & Wilcox water-tube boiler of the marine type, and one 100 H. P. Babcock & Wilcox water-tube boiler of the standard type, both of which are fitted with internal superheaters. There is also one 80 H. P. Heine water-tube boiler and one 25 H. P. Roberts safety boiler connected with a Foster independent superheater. The auxiliary apparatus consists of a Cochrane open heater, a Wainwright closed heater, steam pumps, traps, injectors, etc. A full set of scales, measuring tanks, gauges, flue gas apparatus, separating and throttling calorimeters, pyrometers, etc., completes the boiler equipment.

The Gas Engine Laboratory. The equipment consists of an 8 H. P. Westinghouse gas engine, an 8 H. P. Olds gasoline engine, an 8 H. P. Fairbanks gasoline engine, a 6 H. P. Hornsby-Akroyd oil engine, a 12 H. P. Priestman oil engine, a 16 H. P. Acme gas engine run on producer gas from a 15 H. P. suction gas-producer, and a 30 H. P. three-cylinder Westinghouse gas engine with gas producer. This last engine may also be operated with illuminating gas. Hot air engines are represented by a Rider and an Ericsson engine. This engine equipment is chosen to give as great a variety as possible in the fuel used, types of governing, etc.

The laboratory has a special testing floor and is well equipped for investigations and tests.

The supply of testing instruments includes several outside-spring indicators, optical indicators, and a manograph. For temperature measurements there are available high reading thermometers and pyrometers of the expansion and electrical types.

The Hydraulic Laboratory. This laboratory contains the following machines and apparatus: a 3-inch single stage De Laval centrifugal pump; a 2½-inch two-stage Worthington centrifugal pump; a 12-inch Doble water wheel; a 12-inch mixed-flow reaction turbine; several Pelton wheels and hydraulic rams; sets of weir boxes with various types of weirs and nozzles for the determination of coefficients of discharge; various types of water meters and other apparatus for measuring the flow of water, such as Pitot tubes, Venturi meters, current meters, etc.

The Oil Testing Laboratory. This laboratory contains a Cornell oil testing machine, a Thurston standard railway testing machine, and several smaller Thurston machines. The rest of the equipment consists of several viscosimeters of different types, together with the necessary hydrometers and thermometers.

The Refrigeration Laboratory. For the study of refrigeration in all its phases, the mechanical laboratory possesses a very complete York refrigerating plant having a capacity of 15 tons of ice, besides a Brunswick and a De La Vergne machine of small size.

The Cement Laboratory. This laboratory not only contains the ordinary apparatus for the testing of cement and concrete but in addition is equipped with crushing and grinding machinery and a small vertical kiln for making investigations on the manufacture of cement from raw material.

The Fuel Testing Laboratory. This laboratory contains a complete equipment of fuel calorimeters, and other apparatus needed for the determination of the composition and calorific value of fuel, whether gaseous, liquid, or solid.

The miscellaneous laboratory equipment includes Morin and Webber transmission dynamometers, a Reeves variable speed transmission, and a belt testing machine, by means of which not only the efficiency of transmission but also the amount of belt slip and the coefficient of friction may be determined.

THE ELECTRICAL EQUIPMENT

The Department of Electrical Engineering is fully equipped with modern apparatus for experimental lectures, laboratory practice, plant testing, standardizing of instruments, and investigation. This apparatus has been selected primarily to exemplify modern shop tests and to familiarize the student with the practical apparatus as well as with the theory of operation of electrical devices.

The Lecture Equipment. In addition to the usual complement of apparatus for demonstration, the lecture equipment includes an air-insulated, high-pressure transformer, with necessary regulators for subjecting insulators and insulating material to alternating pressures up to 60,000 volts. This can be supplemented by additional transformers for raising the pressure still higher. A 30,000 volt transformer provides current for wireless telegraphy. All the standard equipment, as well as many pieces of specially designed apparatus, are employed to illustrate the operation of the principal laws applied in electrical engineering. Exhibits of apparatus, such as street railway car controllers, rail sections, insulating and line material, etc., are provided in profusion. This list includes a complete outfit for exhibiting in actual operation the multiple system of electric car control. An electric elevator and an overhead traveling crane system permit the laboratory motors and generators to be brought into the lecture room and class room for purposes of operation and illustration.

The Laboratories. The laboratory apparatus comprises a full complement of modern alternating and direct current machinery of all kinds. The alternating current equipment includes single and polyphase alternators and synchronous motors, induction motors, transformers, and all apparatus auxiliary thereto. A variety of direct current dynamos and motors suitably mounted for testing, cover the field of direct current machinery. There is a large supply of ammeters, voltmeters, and wattmeters of all types and ranges. A De Laval steam turbine geared to a direct-current generator, a direct connected marine set, circuit breakers, switches, water rheostats, and other auxiliaries are in use for plant test experiments. A 35 K. W. direct-connected turbo-generator is also available. The plant testing is done largely outside of the college buildings and for this purpose a large variety of ammeters, voltmeters, wattmeters, and other instruments are maintained in adjustment at a high standard of accuracy. These instruments have capacity great enough for testing the largest power plants. Special facilities are provided for the standardization of all electrical apparatus. Board of Trade and Reichsanstalt standards of resistance with large current carrying capacity, potentiometers and galvanometers, and reference standards of electro-motive forces are among the facilities provided for this purpose. In addition to the apparatus in the laboratories, the students may observe in operation a three-phase power transmission in the local power and lighting service. Large direct-connected generators, rotaries, constant current regulators and induction motors, as well as the lighting and railway system are convenient for inspection. The University has a modern hydro-electric plant containing large three-phase

alternators direct driven by Doble impulse water-wheels. The power station also contains smaller units for direct current supply with all necessary auxiliary apparatus.

ENGINEERING RESEARCH EQUIPMENT

For use in connection with the investigations conducted in the Department of Engineering Research the equipment and resources of all departments of Sibley College are available, and in most instances, arrangements can be made to use the equipment of the scientific and engineering departments of the other colleges of the University.

ENGINEERING LIBRARY

In addition to the well equipped engineering library located in the college the student has access to the University Library and to the special libraries of the other colleges of the University.

SCHOLARSHIPS AND PRIZES

A special pamphlet on prizes may be secured from the Registrar. A description of the scholarships open to entering freshmen is given in the General Circular of Information.

Particular attention is directed to the two following paragraphs. These competitions are open only to students in Sibley College.

Sibley Prizes in Mechanic Arts. Under the gift of the late Hon. Hiram Sibley, made in 1884, the sum of one hundred dollars will be annually awarded in five prizes to juniors and seniors in Sibley College who have received the highest marks in scholarship in at least three full terms of work required in the Sibley College course and done in Cornell University. The prizes are $30, $25, $20, $15, and $10.

The Frank William Padgham Scholarship, covering tuition and fees in Sibley College, will be assigned to the best competing candidate in the scholarship examinations, who has had his preparatory education in the public schools of Syracuse, N. Y. The examination subjects are mathematics, French, German, and English, and examinations must be taken in three of these subjects, of which one must be mathematics. The holder shall pursue the regular course in Mechanical Engineering in Sibley College, and will be excused from the payment of tuition and the regular Sibley College fee.

COURSES OF STUDY

The following courses of study are offered:

1. The regular course in the Sibley College of Mechanical Engineering and the Mechanic Arts, leading to the degree of Mechanical Engineer and covering a period of four years.

2. A five-year course, in which the student is during his first two years of residence registered in the College of Arts and Sciences. The five-year course leads to the degree of Mechanical Engineer.

3. A six-year course, in which the student is during his first three years of residence registered in the College of Arts and Sciences. The six-year course leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Mechanical Engineer at the end of the sixth year.

These courses are separately described on pages 17, 21, and 22.

1. THE FOUR-YEAR COURSE LEADING TO THE DEGREE OF MECHANICAL ENGINEER

In the regular four-year course leading to the degree of Mechanical Engineer, instruction is the same for all students during the first three years. In the fourth year, some opportunity is offered for specializing in the different branches of mechanical and electrical engineering.

The sequence of subjects in the four-year course and the time devoted to each course, are tabulated below. The detailed descriptions of the courses are given on pages 23 to 36.

Schedule of Four-Year Course

In referring to courses the following abbreviations are used: Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Machine Design, D; Shop, S; Engineering Research, R. For description of courses given by other colleges, see pages 23 to 24.

About three hours of actual work in shops, laboratories, computing work, or drawing count as one hour credit in the schedule.

FRESHMAN YEAR

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry	23	5a	4	0
Differential Calculus	23	5b	1	2
Integral Calculus	23	5c	0	4
Chemistry	23	1	0 or 6	6 or 0
Physics Lectures	23	1	4 or 0	0 or 4
Physics Recitations	23	5	2 or 0	0 or 2
Drawing and Desc. Geom	25	D1	3	3
Foundry	25	S3	2 or 0	0 or 2
Forge	25	S4	0 or 1	1 or 0
Engineering Principles	25	S2	0 or 1	1 or 0
Military Drill		1	1	1

SOPHOMORE YEAR

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	24	M5, 6	5	5
Physics Recitations	23	8, 9	2	2
Physics Laboratory	23	14	2	2
Chemistry	24	6	0 or 5	5 or 0
Kinematics	26	D6	0	2
Drawing	26	D5, 7	3	3
Materials	28	X6	2 or 0	0 or 2
Pattern Making	25	S7	3 or 0	0 or 3

In addition to the above, three hours a week of either Military Drill or Physical Culture must be taken in the sophomore year.

Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Heat-Power Engineering	30	P10	3	3
Electrical Machinery, Lectures, Recitations, and Laboratory	32	E10, 11	4	4
Mechanical Laboratory	29	X10	3	0
Mechanical Laboratory	29	X11	0	3
Machine Design				
(a) Lectures and recitations	27	D16	3	2
(b) Drawing	27	D10	2	2
Machine Work	25	S10	2	2
Principles of Manufacturing	25	S11	2	0
Hydraulics	25	M12	2 or 0	0 or 2

Senior Year

In the senior year the student must complete one of the following groups:

Group A. Steam Power Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	31	P20	3	3
Mechanical Laboratory	29	X20, 21	3	3
Electrical Laboratory	35	E29	3 or 0	0 or 3
*Electrical Engineering Problems	36	E31	0 or 2	2 or 0
*Industrial Organization	26	S20	2	0
Economics	24	52	2	2
Steam Machinery Design	31	P21	3	3
Designing and Drawing	31	P22	3	3
Steam Turbines	32	P25	0	2
*Thesis (Elective)				

Group B. General Mechanical Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	31	P20	3	3
Mechanical Laboratory	29	X20, 21	3	3
Electrical Laboratory	35	E29	3 or 0	0 or 3
*Electrical Engineering Problems	36	E31	0 or 2	2 or 0
*Industrial Organization	26	S20	2	0
Economics	24	52	2	2
General Engineering Design	27	D22	3	3
Designing and Drawing	27	D23	3	3
Structural Engineering	31	D24	2	0
*Thesis				

*By petitioning the Faculty on or before Oct. 31, a student may offer a thesis, or investigation, as a substitute for E31 and S20. (See course R27, page 30.)

Group C. Gas Power Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	31	P20	3	3
Mechanical Laboratory	29	X20, 21	3	3
Electrical Laboratory	35	E29	3 or 0	0 or 3
*Electrical Engineering Problems	36	E31	0 or 2	2 or 0
*Industrial Organization	26	S20	2	0
Economics	24	52	2	2
Gas Machinery Design	32	P26	3	3
Designing and Drawing	32	P27	3	3
Gas Manufacture	32	P28	2	0
*Thesis				

Group D. Electrical Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	31	P20	3	3
Mechanical Laboratory	29	X20	3	0
Electrical Laboratory	35	E28	4	4
Electrical Engineering	33	E20	2	2
Electrical Engineering	33	E21	4	4
*Industrial Organization	26	S20	0	2
Economics	24	52	2	2
*Elective†	33–36		0 or 2	2 or 0
*Thesis				

*By petitioning the Faculty on or before Oct. 31, a student may offer a thesis, or investigation, as a substitute for S20 and E31 (or the elective subject of group D). See course R27 on page 30.
†Limited to E22, 23, 24, 25, 26 and Phys. 33 and 34.

Suggested Technical Electives

These electives may be taken only with the approval of the Class Adviser and of the departments concerned. For detailed information see announcements of the departments giving the courses.

For Seniors Only

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Thesis	30	R27	0–8	8–0
Steam Boiler Design	31	P23	2	0
Steam Turbines	32	P25	0	2
Gas Manuf. and Distribution	32	P28	2	0
Gas Power Machinery	32	P29	0	2
Advanced Heat-Power Engineering	32	P40	1–3	1–3
Engineering Research	30	R22	1–3	1–3
Power Plant Testing	30	R23	1–3	1–3
Motor Car Construction	30	R24	0	1
Heating and Ventilating	30	R25	0	2
Mechanical Refrigeration	29	X26	0	2
Structural Engineering	27	D24	2	0

FOR SENIORS ONLY

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Ship Design	28	D26	0	3
Structure and Strength of Ships	28	D27	0	3
Resistance, Propulsion, etc	28	D28	0	2
Aerial Engineering	28	D25	2	0
Advanced Designing	28	D40	1–3	1–3
Special Elect. Eng. Problems	36	E33	1–3	1–3
Engineering Mathematics	35	E30	2	2
Railway Cons. and Maintenance		C.E.63	0	2
Concrete Construction		C.E.77	3	3
Alternating Currents		Phys. 33	2	0
Electrical Lab. Practice		Phys. 34	3 or 0	0 or 3

FOR E. E. SENIORS ONLY

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Design of Elect. Machinery	34	E22a	0	2
Design of Elect. Machinery	34	E22b	0	2
Gen. and Dist. of Elect. Energy	34	E23a	2	0
Gen. and Dist. of Elect. Energy	34	E23b	0	2
Advanced Electric Railways	35	E26a	0	2
Advanced Electric Railways	35	E26b	0	2

Students having the necessary preparation and having the approval of their Class Adviser may take subjects in the following list in any year, except when the year is indicated by a figure immediately following the subject. The choice of studies is not limited to this technical list; the student may, with the approval of his Class Adviser and of the department concerned, take any subject in any department in the University.

Course	No. Course	Hours 1st Term	Hours 2d Term
Surveying	C.E.12	0	2
Spec. and Contracts (3 or 4)	C.E.90	0	2
Elem. of Elect. Ry. Pract. (3 or 4)	E25	2	0
[Illuminating Eng. (3 or 4) Not given in 1912–13	E32	0	3
Intelligence Transmission Engineering (3 or 4).	E24	0	3
Assaying	Chem. 18	3	0
Adv. Quant. Anal.	Chem. 14	1–3	1–3
Adv. Quant. Anal.	Chem. 15	2	0
Qual. and Quant. Gas Anal.	Chem. 19	1	0
Tech. Gas Anal.	Chem. 20	2	0
Photometry	Phys. 15	1–3	1–3
Photom. and Illum.	Phys. 43	2	0
Photography	Phys. 18	2 or 0	0 or 2
Bldg. Stone and Clay Prod.	Geol. 30	0	2 or 3
Practical Geology	Geol. 31	3	3
General Econ. Geol	Geol. 32	2 or 3	2 or 3
Mining of Mineral Deposits	Geol. 34	2	2

2. A FIVE-YEAR COURSE LEADING TO THE DEGREE OF MECHANICAL ENGINEER

Requirements for Admission

The requirements for admission to the five-year course are those of the College of Arts and Sciences, in which college the student will be registered for the first two years. For these requirements see page 6 of the General Circular of Information. Before transferring to Sibley College at the beginning of his third year of residence, the student must have satisfied all the specific entrance requirements for the regular four-year course in Sibley College and must have conformed to the outline of the first two years of the course as given below.

Outline of Course

The outline of the first two years gives the subjects which must be taken in order that the student may enter the third year properly prepared for the engineering work. It is essential that the student should follow the sequence of subjects as given in this outline, for otherwise it may be impossible for him to complete the requirements for the degree by the end of the fifth year.

In referring to courses of instruction the following abbreviations are used: Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Machine Design, D; Shop Work, S. For description of courses given in Sibley College see page 24; for description of courses give by other colleges, see the announcements of those colleges.

FIRST YEAR (in the College of Arts and Sciences)

Course	No. Course	Hours 1st Term	Hours 2d Term
Solid Geometry	1	3	0
Trigonometry	3	3	0
Advanced Algebra	2	0	5
Chemistry	1	0	6
Drawing	D3	3	0
Engineering Principles	S2	0	1
Elective in Arts (as stipulated in the regulations of the College of A. and S.)		9	6

SECOND YEAR (in the College of Arts and Sciences)

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytical Geometry	23	5a	4	0
Differential Calculus	23	5b	1	2
Integral Calculus	23	5c	0	4
Chemistry	24	6	5	0
Physics Lectures	23	1	0	4
Physics Recitations	23	5	0	2
Descriptive Geometry	26	D 2	0	3
Foundry	25	S 3	2	0
Elective in Arts			6	3

THIRD YEAR (in Sibley College)

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	24	M5, 6	5	5
Physics Recitations	23	8, 9	2	2
Physics Laboratory	23	14	2	2
Kinematics	26	D6	0	2
Drawing	26	D5, 7	3	3
Materials	28	X6	2	0
Forge Work	25	S4	1	0
Pattern Making	25	S7	0	3
Elective in Arts			4	2

FOURTH AND FIFTH YEARS

The fourth and fifth years are identical with the third and fourth years of the regular four-year course (see pages 18, 19).

3. A SIX-YEAR COURSE LEADING TO THE DEGREES OF A.B. AND M.E.

A student in the College of Arts and Sciences who has satisfied at least six terms of residence, no one of them under the provisions of paragraphs (2) or (3) page (i) of Announcement of Courses of Instruction in the College of Arts and Sciences, and who has a credit of at least ninety hours, may with the permission of the faculties concerned be registered both in the College of Arts and Sciences and also in any other college of Cornell University.

This provision enables a student who so desires, to obtain the degree of A.B. from the College of Arts and Sciences at the end of four years, and the degree of M.E. from Sibley College at the end of six years. Advice and assistance in arranging such a course may be had by applying to the Director of Sibley College and the Dean of the College of Arts and Sciences.

In order to make it possible to secure the M.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects, listed on page 17, before the beginning of his fourth year, and must complete the list of sophomore subjects (page 17) before the beginning of his fifth year.

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VOLUME III NUMBER 4

Sibley College of Mechanical Engineering and the Mechanic Arts Announcement, 1912–13

GROUP E—MINING ENGINEERING

Students who have satisfied the entrance requirements as outlined on page 6 of the Announcement may substitute, in place of the regular course given on pages 17 to 19, the following four-year schedule of subjects relating to Mining Engineering and leading to the degree of Mechanical Engineer.

NOTE. In referring to courses, the following abbreviations are used: Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Machine Design, D; Shop, S; Engineering Research, R.

About three hours of actual work in shops, laboratories, computing work, or drawing count as one hour credit in the schedule.

FRESHMAN YEAR

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry	23	Math. 5a	4	0
Differential Calculus	23	" 5b	1	2
Integral Calculus	23	" 5c	0	4
Chemistry, Introductory Inorganic	23	Chem. 1	6	0
Chemistry, Qualitative Analysis	53*	" 7	0	6
Physics Lectures	23	Phys. 1	4	0
Physics Recitations	48*	" 6	0	4
Forge-Shop	25	S4	0	2
Drawing	26	D3	3	0
Military Drill		1	1	1

SOPHOMORE YEAR

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	24	M5, 6	5	5
Chemistry, Quantitative Analysis	53*	Chem. 12	6	0
Physics Laboratory	23	Phys. 14	0	4
Crystallography	71*	Geol. 12	3	0
Mineralogy	72*	" 13	0	3
Elementary Geology	70*	" 1	3	3
Descriptive Geometry	26	D2	0	3

In addition to the above, three hours a week of either Military Drill or Physical Culture must be taken in the sophomore year.

*These refer to pages in the Coures of Instruction of the College of Arts and Sciences, 1911–12, which may be had upon application to the Registrar of Cornell University, Ithaca, N. Y.

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Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Kinematics	26	D6	0	2
Drawing	26	D5, 7	3	3
Hydraulics	25	M12	2	0
Heat Engines	31	P11	0	3
Metallurgy of Iron and Steel	—	X 7	3	0
General Econ. Geology	73*	Geol. 32	3	3
Mining of Mineral Deposits	73*	" 34	3	3
Surveying		C.E. 10, 11	3	4

During the summer following the junior year the student is required to devote about eight weeks to field work in Mining and Ore Dressing.

Senior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Assaying	54*	Chem. 18	3	0
Blow Pipe Analysis	72*	Geol. 14	1	0
Machine Design				
(a) Lectures and Recitation	27	D16	3	2
(b) Drawing	27	D10	2	2
Mining Methods and Design	—	D39	2	4
Materials Laboratory	29	X10	3	0
Mechanical Laboratory	29	X11	0	3
Examination of Mineral Deposits	73*	Geol.33	0	2
Electrical Engineering	33	E12	3	0
Machine Shop	25	S10	0	2
Elective †			2	4

*These refer to pages in the Courses of Instruction of the College of Arts and Sciences, 1911–12.
†It is recommended that the student elect, with the consent and aid of his class adviser, such other courses as may seem desirable or necessary for the special work the student expects to enter.

COURSES OF INSTRUCTION

SUBJECTS GIVEN IN THE COLLEGE OF ARTS AND SCIENCES

5. **Analytic Geometry and Calculus.** Twenty-four sections, daily except S, first term; daily, second term. Under the direction of Professor TANNER.

5a. Analytic Geometry. Credit four hours first term.

5b. Differential Calculus. Credit one hour first term, two hours second term.

5c. Integral Calculus. Credit four hours second term.

1. **Introductory Experimental Physics.** Repeated in second term, credit four hours. Professors NICHOLS and SHEARER, and Mr. GIBBS. M T W Th, first term 9 or 12, second term 12, Rockefeller A.

Entrance Physics is not accepted as an equivalent for this course.

5. **Introductory Physics.** Class room work. Repeated in second term, credit two hours. Messrs. GIBBS, AYERS, BUCKLEY, DAVEY, FORMAN, HOWES, RODGERS, and THOMPSON. M W, or T Th, Rockefeller, to be assigned.

8. **General Physics.** Theory. First term, credit two hours. Prerequisite courses 1 and 5 and Mathematics 5. Messrs. FISHER, GALAJIKIAN, MAYER, MOLBY, NASMYTH, SOMERVILLE, and TAYLOR. Two days as assigned, Rockefeller as assigned.

Textbook work in statics, dynamics, properties of matter, electrostatics, and magnetism. Two hours of course 14 must be taken in connection with course 8.

9. **General Physics.** Theory. Second term, credit two hours. Prerequisite course 8 and the first term of 14. Instructing staff as in course 8. Two days as assigned, Rockefeller as assigned.

Textbook work. A continuation of course 8. Current electricity, heat (including thermometry, expansion, calorimetry, radiation, and conduction, properties of vapors, and an introduction to the kinetic theory of gases), and thermodynamics. Two hours of course 14 must be taken with course 9.

14. **Physical Experiments.** Throughout the year, credit two hours a term. Prerequisite courses 1 and 5. Assistant Professors BLAKER and RICHTMYER, and Messrs. FISHER, GALAJIKIAN, MAYER, MOLBY, NASMYTH, SOMERVILLE, and TAYLOR. Rockefeller 250–257 as assigned.

Physical measurements, properties of matter, mechanics, heat, light, sound, magnetism, and electricity; the adjustment and use of instruments of precision. Results and errors are carefully discussed. Two hours of course 14 must be taken with course 8 and two hours with course 9.

1. **Introductory Inorganic Chemistry.** Lectures, recitations, and laboratory. Repeated in second term, credit six hours.

1a. Lectures. First term, M W F, 11, Professor DENNIS and Mr. M. J. DAVIS; T Th S, 11, Professor BROWNE and Mr. M. J. DAVIS. Second term. M W F, 11. Morse 1.

1b. Recitations (one hour a week), and laboratory (two 2½ hour periods a week) to be arranged. Professors DENNIS and BROWNE, Mr. WELSH, and Messrs. HOULEHAN, SHERWOOD, FINK, CORRUTH, OVERMAN, GILBERT, and HOOEY.

Examinations for those who were unavoidably absent for the Final Examination in Course 1, and for those who have conditions to remove, will be held at 2 p. m. September 25, 1912, and also in the month of May, 1913, at a date to be announced. No special examinations will be given at other times.

6. **Qualitative and Quantitative Analysis.** Repeated in second term, credit five hours. Prerequisite course 1. Mr. LEMON, and Messrs. UHLRICH, GIBBONS, YOUNT, ELLIOT, BRODERSON, BEAGLE, and MONTGOMERY. Lectures, T Th, 12, Morse L. R. 1.

Laboratory sections: M W F, 2–5; T Th S, 8–11; T Th S, 9–12.

Qualitative work: the properties and reactions of the common elements and acids and their detection in various liquid and solid mixtures.

Quantitative work: the preparation and use of volumetric solutions and work in elementary gravimetric analysis.

Examinations for those who were unavoidably absent from the final examination in Course 6 will be held at 2 p. m. September 25, 1912.

52. **Elements of Economics.** A special course for engineering students. Seniors. Throughout the year, credit two hours a term. Production and distribution of wealth, emphasizing particularly the financial or practical view instead of the theoretical. Lectures, textbook readings, and class discussions. Assistant Professor BAUER.

Electives. Sibley students who have the time available may take any course in any college in the University provided they have the approval of their Class Adviser and of the department concerned.

SUBJECTS GIVEN IN SIBLEY COLLEGE

The courses in each department in Sibley College are numbered in accordance with the following plan:

Numbers	1	to	4	inclusive denote	freshman subjects.
"	5	to	9	" "	sophomore "
"	10	to	19	" "	junior "
"	20	to	39	" "	senior "
"	40	to	45	" "	graduate "

About three hours in shops, laboratories, computation work, or drawing count as one credit hour in the schedule.

Department of Mechanics of Engineering

M. 5 and 6. **Mechanics of Engineering.** Sophomores. M. 5 in first term, M. 6 in second term. Credit five hours a term. Prerequisite Mathematics 5. Theoretical and applied mechanics with mathematical and graphical treatment; statics of a material point and of rigid bodies,—resolution and composition of forces and couples, centers of gravity, moments of inertia, framed structures, graphical statics; kinetics of a material point and of rigid bodies, with application to mechanisms,—motions, velocities, accelerations, centrifugal and inertia forces, impact, energy, work, power, friction, and graphics of machines; and mechanics of materials,—stresses, strains, resilience, forces, and moments produced by loads acting on structural members, (simple beams, cantilevers, continuous girders, shafts, columns, etc.), and strength, rigidity, and flexure of members, etc.;

hydrostatics,—pressures in tanks, centers of pressure and floatation. Professor WOOD, Assistant Professor GARRETT, and Messrs. CORNELL, DOUGLASS, FRANCIS, and FRIED.

M. 12. **Hydraulics.** Juniors. Either term, credit two hours. Prerequisite M. 5 and 6. Hydrokinetics, flow through orifices and over weirs; general equation of energy; losses of head; flow in pipes and open channels; dynamic action of streams; general theory of turbines with applications to tangential water wheels, reaction turbines and centrifugal pumps. Professor WOOD and Acting Assistant Professor DAUGHERTY.

M. 21. **Hydraulic Turbines.** Elective. Seniors. Either term, credit one hour. Prerequisite M. 12. A lecture course on the features of construction and installation of modern hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type and size of turbine for any given set of conditions. Professor WOOD and Acting Assistant Professor DAUGHERTY.

Department of Machine Design and Construction

Machine Construction

S. 2. **Engineering Principles.** Freshmen. Either term as assigned, one hour credit. First half of the term, discussion of the general principles that underlie the transmission of energy from natural sources. Professor SMITH. Second half of the term, a discussion of the applications of energy. Mr. WELLS.

S. 3. **Foundry Work.** Freshmen. Either term, two hours credit. Six hours of work a week. Moulding, core making, mixing, and casting of metals, use of moulding machines. Demonstration of large work and production in quantities. Daily 8–11, 11–2, 2–5, as assigned. Messrs. VANDERHOEF and DAVIES.

S. 4. **Forge Work.** Freshmen. Either term, one hour credit. Three hours of work a week. Forging, welding, tool dressing, tempering, etc., together with demonstrations in the production of drop forgings. Daily 8–11, 11–2, 2–5, as assigned. Messrs. HEAD and BROOKS.

S. 7. **Pattern Making.** Sophomores. Either term, three hours credit. Nine hours of work a week. Prerequisite S. 3. Use of hand and machine tools for wood working, followed by graded instruction in pattern making, construction of core boxes, etc. Daily 8–11, 11–2, 2–5, as assigned. Messrs. HOOPER, SEAMAN, BUSH, and SWEET.

S. 10. **Machine Work.** Juniors. Throughout the year, credit two hours a term. Six hours of work a week. Prerequisite S. 3, 4, and 7. Use of measuring instruments, hand and machine tools, fitting, and assembling. Operation and use of jigs and other manufacturing fixtures. Operation of semi-automatic and automatic machines and the illustration of manufacturing methods generally as discussed in course S. 11. Must be accompanied by S. 11 in the first term. Daily 8–11, 11–2, 2–5, as assigned. Messrs. WELLS, HOWE, SMITH, and BUCK.

S. 11. **Principles of Manufacturing.** Juniors. First term only, two hours credit. This course must be taken in connection with course S. 10. Lectures on theory of measuring instruments, shop tools, and equipment; shop processes;

manufacturing methods; theory of costs and time keeping systems; factory management. Mr. WELLS.

S. 20. **Industrial Organization.** Seniors and graduates. Either term, two hours credit. Prerequisite S. 10 and S. 11. Lectures giving a more extended discussion of the finance of manufacturing, supplemented by an inquiry into the reasons for certain modern tendencies such as factory legislation and factory welfare work; methods of rewarding labor, bonus and profit sharing schemes, etc., etc. Professor KIMBALL.

Machine Design

D. 1. **Drawing and Descriptive Geometry.** Freshmen. Throughout the year, credit three hours a term. Nine hours of work a week. Lettering (proficiency in at least one style of simple lettering); descriptive geometry (lectures and drawing)—including lines, planes, solids, tangents, intersections, sections, developments,—with solutions in all quadrants; isometric projection; mechanical drawing; working drawings, including conventions, standards, etc., following the best practice of commercial drafting rooms. Messrs. WILLIAMS, ELLIOTT, EATON, LEE, MILLS, and TOWNSEND.

D. 2. **Descriptive Geometry.** Second year students in the five-year course only. Second term, credit three hours. Nine hours of drawing a week. The same work in descriptive geometry as that given in connection with course D 1. Messrs. WILLIAMS, ELLIOTT, and LEE.

D. 3. **Drawing.** For students registered for the degree of Bachelor of Chemistry in the College of Arts and Sciences, and for first year students in the five-year course. First term, three hours credit. Nine hours of drawing a week. Mechanical drawing; working drawings, including conventions, standards, etc., following the best practice of commercial drafting rooms. Drawing same as that given in connection with course D. 1. Messrs. WILLIAMS and EATON.

D. 5. **Machine Drawing.** Sophomores. First term, credit three hours. Nine hours of drawing a week. Prerequisite course D. 1. Application of the work of course D. 1 to machine drawing in connection with empirical designing; proportioning of machine details as fixed by common practice rather than by mathematical theory; making and using standard data sheets; making of assembly drawings. Assistant Professor HAYES, and Messrs. PEACH, KLINCK, CAUTLEY, and THORNE.

D. 6. **Kinematics.** Sophomores. Second term, credit two hours. Prerequisite course D. 1 (or D. 2 and 3), and must be taken with course D. 7. Two recitations a week on the theory of mechanisms, instant centers, cams, gears, linkages, velocity, and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. PEACH, KLINCK, CAUTLEY, and THORNE.

D. 7. **Kinematic Drawing.** Sophomores. Second term, credit three hours. Nine hours of drawing a week. Prerequisite course D. 1 (or D. 2 and 3) and must be taken with course D. 6. Drawing board application of the work in course D. 6. Solution of mechanisms by means of instant centers, the designing of cams, gears, linkages, etc., drawing of velocity and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. PEACH KLINCK, CAUTLEY, and THORNE.

D. 10. **Drawing and Design.** Juniors. Throughout the year, credit two hours each term. Six hours of drawing a week. Prerequisite courses D. 5, D. 6, D. 7, M. 5 and 6, and must be taken with course D. 16. Drawing room problems in elementary machine design illustrating the work as given in D. 16. The student for the first time undertakes the design of a complete machine, laying out the general outlines, proportioning the details theoretically, and modifying his results by practical considerations. All computations necessary for the complete design must be carefully and systematically made. Working drawings of the most important details and a finished assembly drawing are completed. Professor KIMBALL, Assistant Professor ALBERT, and Messrs. ADLER, CORWIN, DU PRIEST, and PEIRCE.

D. 16. **Machine Design.** Juniors. First term, one lecture and two recitations a week; second term, one lecture and one recitation a week. Three hours credit first term and two hours second term. Prerequisite courses D. 6, D. 7, M. 5 and 6, and must be taken with D. 10. Selection of mechanism for specified work and study of practical considerations involved. Analysis of energy and force problems in machines. Determination of driving devices as based on work to be done. Proportioning of detail parts as dictated by stress and practical considerations. Applications of the laws of mechanics and kinematics to the design of machines and a discussion of empirical design and modifications due to practical considerations. Professor KIMBALL, Assistant Professor ALBERT, and Messrs. ADLER, CORWIN, DU PRIEST, and PEIRCE.

D. 22. **General Engineering Design.** Required of seniors in group B. Throughout the year, three hours credit each term. Lectures. Prerequisite D. 10, D. 16, and P. 10, and must be taken with D. 23. For students who do not wish to specialize in any particular branch of engineering but wish to get a general knowledge of mechanical engineering design and construction. The work of the first term consists of a discussion of the problems met with in the design, construction, and equipment of mills, factories, etc., including foundations, walls, floors, trusses, roofs, and mill and construction work in general; powering of factories, motor driving of machine tools, etc. In the second term this work is applied to the outline design of a complete power house, including the location of plant; track and wharf facilities; selecting and locating boilers and engines; coal storage, coal and ash handling equipment; selection and arrangement of condensers, pumps, steam piping, etc. Professor HESS, and Messrs. FREEMAN, and HAM.

D. 23. **Drawing and Design.** Nine hours of work a week throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16 and P. 10, and may only be taken in connection with D. 22. Design and drawing of various classes of work illustrating the principles discussed in D. 22. Graphical analysis of stresses in trusses and other structures. In the second term, drawings are made for the complete outline design of a power house as outlined under course 22. Professor HESS, and Messrs. FREEMAN, and HAM.

D. 24. **Structural Engineering.** Seniors. First term, credit two hours. Prerequisite courses D. 10 and 16. Fundamental principles underlying the design and construction of framed structures, involving the use of wood, steel, brick, stone, concrete, reinforced concrete, etc., singly and in combination.

Application to the design of buildings suitable for engineering shops and factories. Foundations for the walls and machinery, taking into account the character, stable and otherwise, of soil-bottom and nature of the loads. Framing and construction of the side and division walls, floors and roofs. Discussion of the various materials which may be employed. Modern methods of lighting and ventilation. Paints and other protective coatings for metallic and wooden structures. The relative costs of construction, upkeep, and repairs. Professor McDERMOTT.

D. 25. **Aerial Engineering.** Seniors. First term, credit two hours. Prerequisite courses M. 5 and 6, D. 10 and 16. Physics of the atmosphere; physical properties and technique of the gases used in aerostatics and dirigibles. Aerodynamics; theory of aerodynamic support and resistance of bodies in motion, with special reference to the results of modern experimental research. Construction of air-craft, suitable machinery, and propellers. Professor McDERMOTT.

D. 26. **Ship Design.** Seniors. Second term, three hours credit. Prerequisite courses M. 5 and 6, D. 10 and 16. Lectures and computations. The conception and derivation of the elements of form; hydrostatic principles involved in the design of vessels; and the most modern methods of computing the geometrical quantities,—displacements, centers of buoyancy, metacenters, moment to trim, initial stability. Register tonnage and freeboard will also be explained. Professor McDERMOTT.

D. 27. **The Structure and Strength of Ships.** Seniors. Second term, three hours credit. Prerequisite courses M. 5 and 6, D. 10, D. 16. Lectures on the structural elements, their functions and interrelations, of the different types of vessels belonging to the mercantile and naval marine. The materials used in shipbuilding and their preservation. The rules and regulations of the chief registration bureaus. In application of the subject matter of the lectures, a scantling section of a typical vessel will be drawn out, and strength calculation made. Professor McDERMOTT.

D. 28. **Resistance, Propulsion, and Powering of Ships.** Seniors. Second term, credit two hours. Prerequisite courses M. 5 and 6, D. 10, D. 16. Lectures discussing the fundamental hydro-dynamic principles involved in the study of the resistance of vessels, and of the different propelling agents, chiefly the screw propeller. The mechanical, space, and weight efficiencies of the different types of propelling machinery,—steam (reciprocating and turbine, singly and in combination) electric, hydraulic, and internal combustion motors—are fully gone into and viewed from the propulsive and commercial efficiency standpoints. Methods of approximating the required horse power, and the determination of the most suitable dimensions of propeller are carefully reviewed, problems being worked out, illustrative of the methods discussed. Professor McDERMOTT.

D. 40. **Advanced Designing.** For graduates who have had the equivalent of D. 22 and D. 23 or of D. 26, 27, and 28. Advanced work in original design as arranged with the head of the Department of Engineering Research and with Professors KIMBALL, McDERMOTT, and HESS.

Department of Experimental Engineering

X. 6. **Manufacture of Engineering Materials.** Required of sophomores. Credit two hours, either term as assigned. Prerequisite Chemistry 1. Two

lectures a week. Metallurgy of iron and steel, copper, etc.; the manufacture of brasses, bronzes, and of other engineering materials. Professor DIEDERICHS.

X. 10. **Mechanical Laboratory—Properties of Engineering Materials.** Juniors. First term, credit three hours. Prerequisite X. 6, M. 5 and 6. One laboratory period a week. Mechanical strength of materials, tension, torsion, transverse, and compression tests; the variation of the mechanical strength with differences in composition or heat treatment; demonstration of different methods of tempering, annealing, forging, etc. The student is required to keep a standard note book, which will be called for at stated intervals for inspection. Professor DIEDERICHS, Assistant Professor UPTON, and Messrs. WIGLEY, CURRENT, BIERMA, HOOK, WING, and ROGERS.

X. 11. **Mechanical Laboratory—Introductory Experimental Engineering.** Juniors. Second term, credit three hours. Prerequisite M. 5 and 6, Chem. 6, Phys. 1 and 5. One laboratory period a week as assigned, one written report a week. Calibration of indicator springs, steam gauges, thermometers, and dynamometers; practice and tests of various computing machines; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; measurement of water; efficiency test of steam engines and pumps, steam heaters, and condensers. Reports are required and these must include all the data and results of the various tests, together with the conclusions. The preparation of the report is considered an important part of the laboratory course. Professor DIEDERICHS, Assistant Professor UPTON, Messrs. WIGLEY, CURRENT, BIERMA, HOOK, WING, and ROGERS.

X. 20. **Mechanical Laboratory—General Experimental Engineering.** Seniors. First term, credit three hours. Prerequisite X. 10, 11, P. 10. One laboratory period a week. Efficiency tests of Corliss compound engine, steam injector, centrifugal blowing fan, Ericsson hot air engine, Rider hot air engine, gas engine with city gas, gas engine with gasoline, and oil engine; tests of hydraulic machinery; pyrometers of various types; and valve setting on automatic and Corliss engines.

Reports are required to be full and complete, to include data and results of each test under consideration, and all information necessary completely to understand the machine tested and the methods used. Professor DIEDERICHS, and Messrs. GAGE, BUNRETT, PUTNAM, HOOK, and CARPENTER.

X. 21. **Mechanical Laboratory — General Experimental Engineering.** Required of seniors. Second term, credit three hours. One laboratory period a week alternating with one computing period. Written report required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: boiler testing and flue gas analysis; triple expansion Corliss engine with heat analysis; De Laval and Curtiss turbines with heat analyses; two-stage air compressor; refrigerating machine; belt testing; flow of water over weirs and through nozzles. Concerning reports see last paragraph under X.20 above. Professor DIEDERICHS, and Messrs. GAGE, BURNETT, PUTNAM, HOOK, and CARPENTER.

X. 26. **Mechanical Refrigeration.** Elective. Seniors and graduates. Second term, credit two hours. Prerequisite P. 10. Lectures on design, operation, and testing of refrigerating systems. Professor DIEDERICHS and Mr. PUTNAM.

Department of Engineering Research

R. 22. **Engineering Research.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have shown proficiency in engineering research. Commercial tests and special problems, which may be carried on in any department of the college, but are under the general supervision of this department. Professor CARPENTER, Assistant Professor SAWDON, and Mr. HYDE.

R. 23. **Power Plant Testing.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors who have shown proficiency in engineering research. Testing of complete power plants as occasion offers. Registration arranged for when opportunities occur. Notices of opportunities will be posted on the department bulletin board. Professor CARPENTER, Assistant Professor SAWDON, and Mr. HYDE.

R. 24. **Motor Car Construction.** Elective. Seniors and graduates. Second term, credit one hour. Two lectures a week, illustrated by lantern slides showing the structure and development of the motor car. Professor CARPENTER.

R. 25. **Heating and Ventilating.** Elective. Seniors and graduates. Second term, credit two hours. Lectures and recitations covering the methods of design and of construction of various forms of ventilating and heating apparatus. Professor CARPENTER.

R. 27. **Thesis.** Seniors. Elective, and may, if approved by the faculty, be offered in place of subjects preceded by an asterisk in the senior groups listed on pages 18 and 19. Either or both terms, maximum total credit eight hours. The work on which the thesis is based must be original investigation. All theses are under the general supervision of the Department of Engineering Research. All students who are considering the preparation of a thesis should consult the head of this department during the junior year if possible; but before the work is undertaken as a substitute for the prescribed courses, the approval of the faculty must be secured. Petitions for approval must be submitted before Oct. 31 of the senior year, and must bear the favorable endorsement of the professor in charge of engineering research. and of the other professors under whom the work is to be conducted. A bound copy of the thesis, in the original typewriting (not a carbon copy) on paper 8 x 10½ inches in size must be deposited at the Director's office before May 15. This copy becomes the property of the University. Professor CARPENTER, Assistant Professor SAWDON, and Mr. HYDE.

Department of Power Engineering

P. 10. **Elementary Heat-Power Engineering.** Required of all juniors. Throughout the year, three hours credit each term. Prerequisite Physics 8, 9, and 14, Chemistry 6, M. 5 and 6, and D. 5, 6, and 7. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors, theoretical cycles and general theory of heat engines; application to steam engines practical modifications in real engines; engine efficiencies and performance; the indicator card as a measure of work and basis for design; economic features,—reduction of losses by jacketing, superheating, compounding, etc., valves and valve gears; types of engines; governors. Acting Assistant Professor ELLENWOOD and Messrs. PARMLEY and ULBRICHT.

P. 11. **Heat Engines and Auxiliaries. (For Civil Engineers.)** Required of all C. E. seniors. Second term only, three hours credit. Not open to Sibley students. Prerequisite Physics 6 and 10, (or the equivalent), Chemistry 1, C. E. 20. Three lectures a week. (a) Elementary consideration of behavior of gases; gas engines. (b) Theory of vaporization; theory of combustion; study of boilers; types of boilers; advantages and disadvantages of various types. (c) Action of vapors in cylinders; steam engines; parts and operation; types, advantages and disadvantages; application; steam consumption and efficiencies. (d) Advantages of condensing; types of condensers; condenser pumps; condenser auxiliaries, as cooling towers, ponds, etc. (e) Pumps; feed pumps, city water works pumps, etc. (f) Contractor's plants; portable and traction engines, hoisting engines, locomotives and similar machinery.

This course is recommended for all students that wish to obtain a general knowledge of steam machinery without great technical detail. Acting Assistant Professor ELLENWOOD and Mr. ULBRICHT.

P. 20a. **Power Plant Design.** Required of all seniors. First term, three hours credit. Prerequisite course P. 10. Two lectures and one recitation a week. A continuation of course P. 10.

Steam turbines; internal combustion engines; principles governing the production and transfer of heat; heating surfaces of boilers; principles of combustion; boiler furnaces and grates; types of boilers; types of stokers; natural and forced draft; producers; feed water heaters; economizers; superheaters; theory of condensation; types of condensers; condenser pumps; cooling towers and similar devices; water treating apparatus, filters, separators, and similar auxiliary apparatus; refrigerating machinery, and air compressors; elementary theory, types, and efficiencies. Professor SMITH and Mr. MATTHEWS.

P. 20b. **Power Plant Design.** Required of all seniors. Second term, three hours credit. Prerequisite P. 20a. Two lectures and one recitation a week. Consideration of selection of elements and their combination in power plants, with the object of producing the maximum profit from investment and operation. Professor SMITH and Mr. MATTHEWS.

P. 21. **Steam Engine Design.** Required of seniors in group A and not open to others. Throughout the year, three hours credit a term. Prerequisite courses D. 10, D. 16, and P. 10, and must be accompanied by course P. 22. Three lectures a week. Discussion of the types, arrangements, and general proportions of steam engines; the theoretical and practical considerations entering into the design of valve gears, and engine details; governor design; balancing; the determination of fly-wheel weights; the selection of the machinery for a steam power plant and its arrangement. Professor BARNARD and Mr. THOMPSON,

P. 22. **Designing and Drawing.** Required of seniors in group A and not open to others. Throughout the year, three hours credit a term. Prerequisite courses D. 10, D. 16, and P. 10, and must be accompanied by P. 21. Three drawing periods a week. A drafting course paralleling the lecture course P. 21, and also including a small amount of turbine design. Professor BARNARD and Mr. THOMPSON.

P. 23. **Steam Boiler Design.** Seniors. First term, two hours credit. Prerequisite courses D. 10, D. 16, and P. 10. Lectures on fuels, combustion, types

of boilers, general proportions, materials, design of boiler details, settings, stokers, accessories, and the equipment and arrangement of boiler plants. Professor BARNARD and Mr. THOMPSON.

P. 25. **Steam Turbines.** Senior elective. Required of group A. Second term, two hours credit. Prerequisite course P. 10. Two lectures a week. Classification of turbines and description of leading features of the various types. Mechanical and thermal consideration underlying the action of steam in turbines. Calculations involved in turbine design. Discussion of building, erecting, and testing. Adaptability to special conditions of service. Economic results of the use of turbines in engineering practice. Professor BARNARD and Mr. THOMPSON.

P. 26. **Gas Machinery Design.** Required of seniors in group C and not open to others. Throughout the year, three hours credit a term. Prerequisite courses D. 10, D. 16, and P. 10. Must be accompanied by courses P. 27 and P. 28. Three lectures a week throughout the year. The rational and empirical design of internal combustion engines and gas producers. Professor HIRSHFELD and Mr. WILSON.

P. 27. **Design and Drawing.** Required of seniors in group C and not open to others. Throughout the year, three hours credit each term. Prerequisite courses D. 10, D. 16, and P. 10. Must be accompanied by courses P. 26 and P. 28. Three drawing periods a week. The practical application of principles discussed in P. 26. Professor HIRSHFELD and Mr. WILSON.

P. 28. **Gas Manufacture and Distribution (General).** Seniors. Required of seniors in group C and open to others having the prerequisites. First term, two hours credit. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. The theoretical and practical principles governing the production and handling of all industrial gases. Professor HIRSHFELD and Mr. WILSON.

P. 29. **Gas Power Machinery (General).** Seniors. Second term, two hours credit. Not open to students taking Group C. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. General theory and salient points in the design and operation of internal combustion engines and gas producers. Description of existing commercial types, study of relative advantages, and consideration of questions of economy. Professor HIRSHFELD and Mr. WILSON.

P. 40. **Advanced Designing in Power Engineering.** Elective for those who have completed the equivalent of the design subjects in senior group A or C. Work and credit as arranged with the head of the Department of Engineering Research and with Professors SMITH, BARNARD, and HIRSHFELD.

Department of Electrical Engineering.

E. 10a. **Elementary Electrical Engineering.** Required of all juniors. First term, one hour credit. Prerequisite Physics 8, 9, and 14, M. 5 and 6. Must be accompanied by E. 10b. One lecture a week. Fundamental laws of electric and magnetic circuits; theory, structure, and operation of electrical machinery; batteries; transmission lines; power plants; substations, etc. Professor NORRIS and Assistant Professor MACOMBER.

E. 10b. **Elementary Electrical Engineering.** Required of all juniors. First term, three hours credit. Must be accompanied by E. 10a. Three recitations a

week. Electric and magnetic circuit problems; theory and operation of generators; motors, transformers. Assistant Professor MACOMBER and Messrs. TAPPAN J. F. STEVENS, FULLER, BALLARD, and A. C. STEVENS.

E. 11a. **Elementary Electrical Engineering.** Required of all juniors. Second term, one hour credit. Prerequisite E. 10a and b. Must be accompanied by E. 11b. One lecture a week. Continuation of E. 10a.

E. 11b. **Elementary Electrical Engineering.** Required of all juniors. Second term, three hours credit. Must be accompanied by E. 11a. One recitation, one laboratory experiment, and one report each week. Examination and operation of electric motors, motor starters, transformers, electric lamps, and telephones. Assistant Professor MACOMBER and Messrs. TAPPAN, J. F. STEVENS, FULLER, BALLARD, and A. C. STEVENS.

E. 12. **Electrical Engineering for Civil Engineers.** Required of all seniors in civil engineering. First term only, three hours credit. One experimental lecture, one recitation, and one laboratory experiment each week. The purpose of the course is four-fold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice; (4) to enable the student to read intelligently electrical engineering literature. Assistant Professor MACOMBER and Messrs. TAPPAN, J. F. STEVENS, FULLER, BALLARD, and A. C. STEVENS.

E. 13. **Electrical Engineering for Chemists.** Required of senior chemists. First term only, four hours credit. One lecture, one recitation, and one laboratory experiment with report each week. The purpose of this course is four-fold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with electrical machinery, and to give him practice in handling it; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice; (4) to enable the student to read intelligently electrical engineering literature. Assistant Professor MACOMBER, Messrs. TAPPAN, and J. F. STEVENS, FULLER, BALLARD, and A. C. STEVENS.

E. 20. **Theory of Electrical Machinery.** Required of seniors in Group D. Throughout the year, two hours credit a term. Prerequisite courses E. 10 and 11. Two lectures a week. First term work covers chiefly the laws of the electric and the magnetic circuit; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance, capacity, and iron loss; theory of transmission lines and transformers. Second term is devoted to the theory of transmission lines, transformers, generators, motors, and rotary converters. The lectures are as far as possible correlated with the work in course E. 21. Professor KARAPETOFF.

E. 21. **Characteristics of Electrical Machinery.** Required of seniors in Group D. Throughout the year, four hours credit a term. Prerequisite courses E. 10 and 11. Two recitations and two computing periods a week. Problems on the work covered by course E. 20; in particular, performance characteristics of transmission lines, transformers, induction motors, alternators, synchronous motors and converters, and direct-current generators and motors. Professor KARAPETOFF and Messrs. DOUGLAS and PERTSCH.

E. 22a. **Design of Electrical Machinery.** Elective for seniors in electrical engineering. Second term only, two hours credit. Prerequisite first term of E. 20 and E. 21. Two recitations a week. Principles of commercial design of electrical machinery.

(1) General data; deduction of principal formulæ used in designing direct and alternating current machinery and transformers; empirical, electrical, and mechanical data. (2) Commercial requirements; cost of manufacturing; requirements of service; guarantees. (3) Deduction of design data from tests on existing machines. (4) Elementary design with given principal dimensions. (5) Selection of principal dimensions for a complete line of similar machines. (6) Mechanical design and preparation of shop drawings. Professor KARAPETOFF and Mr. DOUGLAS.

E. 22b. **Design of Electrical Machinery.** Elective for seniors taking E. 22a. Second term only, two hours credit. Two computation periods a week. The work in the computing room comprises two problems: a complete mechanical design of an electric machine with given principal dimensions, and an electric design of a commercial line of similar machines such as transformers, generators, motors or rotary converters. The work in this course parallels that in E. 22a. Professor KARAPETOFF and Mr. DOUGLAS.

E. 23a. **Generation and Distribution of Electrical Energy.** Elective for seniors in electrical engineering. First term only, two hours credit. Prerequisite E. 10 and 11. Two lectures a week. Selection of apparatus for generating stations and distributing systems. Detail design is omitted, since the purpose of the course is to show standard practice in arrangement and selection of apparatus. The design of the transmission line and of the distributing system is, however, studied in detail, the application of the theory being brought out in lectures and established by practical problems. Assistant Professor FORD.

E. 23b. **Generation and Distribution of Electrical Energy.** Elective for seniors in electrical engineering. Second term only, two hours credit. Prerequisite E. 23a, and first term of E. 20 and 21. Two computing periods a week. The work in this course consists of design problems covering central stations and transmission systems. Assistant Professor FORD.

E. 24. **Intelligence Transmission Engineering.** Elective for juniors and seniors, in alternate years. Given in 1912–13. Second term only, three hours credit. Prerequisite E. 10. Two lectures and one recitation a week. General principles of electrical engineering as applied to modern telegraph, telephone, and other systems of transmission of intelligence. Particular attention is paid to telephony and to problems encountered in telephone engineering. Assistant Professor MACOMBER.

E. 25. **Elements of Electric Railway Practice.** Elective for juniors or seniors. First term only, two hours credit. Prerequisite M. 5 and 6 and Physics 9 and 14. Two lectures a week. Apparatus and construction involved in a modern railway system, including car equipment, trucks, motors, controllers, bodies, accessories, overhead construction, third rail, conduit, and other systems, and other topics of similar character. The underlying idea is to show the application of the general laws of electricity to this particular branch. Some attention is devoted to the relation of electric railways to the public and to finance. Professor NORRIS.

E. 26a. **Advanced Electric Railway Practice.** Elective for seniors in electrical engineering. Second term, two hours credit. Prerequisite first term of E. 20 and E. 21, and E. 25. Two lectures. Fundamental theory of train movement, comprising what may be termed the characteristic curves of railway operation. Professor NORRIS.

E. 26b. **Advanced Electric Railway Practice.** Elective for seniors taking course E. 26a. Second term, credit two hours. Two computing or inspection periods a week. Practice is given in plotting time-speed curves, motor heating curves, railway load curves, drop in transmission lines, etc. Inspections of local equipment are made, including the power house and sub-station of the local railway, track and overhead construction, cars, administration of car barn, etc. The work in this course parallels that in E. 26a. Professor NORRIS.

E. 28. **Electrical Laboratory.** Required of seniors in electrical engineering. Throughout the year, four hours credit a term. Prerequisite X. 11, E. 10 and 11. Two laboratory periods, one recitation, and one report a week. The work during the first term includes the following simple experiments selected from the most important branches of electrical engineering: tests of ammeters, voltmeters, and integrating wattmeters; arc lamps and series arc lighting; electrical relations in transmission lines; characteristics of direct-current generators and motors; commercial tests of transformers; load tests on alternators and induction motors; assembling switchboards, wiring controllers; telephone work, etc. During the second term more advanced experiments are conducted, such as performance tests of transmission lines, transformers, alternators, and induction motors, commercial tests on magnetic qualities of steel and iron; tests of special alternating-current instruments; separation of losses in generators and motors, electrical relations in polyphase systems; operation of rotary converters, electric railway experiments; determination of A. C. wave-form; regulation of storage batteries. Assistant Professor FORD, and Messrs. COLE, STEVENSON, CHAMBERLAIN, and MORROW.

E. 29. **Electrical Laboratory.** Required of all seniors, excepting electrical engineers. First or second term, three hours credit. Prerequisite X. 11, E. 10, and 11, P. 10. One laboratory period, one recitation, and one report a week. The course is arranged for the needs of mechanical engineers, particular attention being paid to the operating features of electrical machinery. The experiments are selected from those given during the first term in course E. 28. Assistant Professor FORD, and Messrs. COLE, STEVENSON, CHAMBERLAIN, and MORROW.

E. 30. **Engineering Mathematics.** Elective. Open to seniors and graduate students only. Throughout the year, two hours credit a term. General methods by which engineering problems are expressed in mathematical form, studied to establish a better understanding of the unity between the instruction in pure mathematics and in the various engineering courses. It is aimed better to prepare the student for engineering research and for the study of advanced engineering literature. The fundamental physical and mathematical assumptions are critically reviewed, and the limitations in the results pointed out. Methods are indicated for obtaining approximate solutions, establishing empirical formulæ, and solving problems by the use of tables, charts, and mechanical devices. The course consists of problems taken from mechanical, civil, and electrical engineering, involving analytic geometry and the elements of differential and integral calculus. Professor KARAPETOFF.

E. 31. **Electrical Engineering Problems.** Seniors in mechanical engineering only. First or second term, two hours credit. Prerequisite E. 10 and 11. A series of problems on electric circuits, machines, and applications. Electrical problems which are met by mechanical engineers in practice. One lecture and one calculation period a week. Mr. TOWER.

[E. 32. **Electrical Illumination Engineering.** General elective for juniors and seniors, in alternate years. Not given in 1912–13. Second term only, three hours credit. Prerequisite E. 10. Students intending to take this course are advised to take Physics 15 and 43 during the first term. A brief review of the theory of illumination, a study of the theory, structure and operation of the various types of electrical illuminating devices, and also the general engineering features of electric lighting systems as a whole, including a discussion of their operation and management.] Assistant Professor MACOMBER.

E. 33. **Special Electrical Engineering Problems.** First or second term, or both. One to three hours. Prerequisite E. 10 and 11. Tests of electrical apparatus both alone and in power plants. The number of students who can be accommodated will depend upon the available opportunity for testing. Professor NORRIS and Assistant Professor FORD.

E. 40. **Advanced Electrical Engineering.** Open to graduate students only. Two to six hours credit each term. The graduate seminar, which forms the basis of this course, meets weekly. Special reports are prepared for these meetings, and thesis work is discussed. Abstracts are made of important engineering publications. Professors NORRIS and KARAPETOFF.